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Early lunar evolution recorded by accessory minerals in meteoritic breccias

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Resolving the timing and effects of crustal formation, intrusive magmatism and impact melt sheet reworking is key to understanding the crustal evolution of rocky planetary bodies. The geochronology of accessory minerals, including zircon, baddeleyite (monoclinic-zirconia), and Ca-phosphates, can elucidate the timing and nature of major events, especially when micro- to nano-structural data are integrated into analysis of mineral histories [e.g. 1,2]. Baddeleyite can provide unique insights, due to phase transformations to and from metastable high-pressure and high-temperature polymorphs [e.g. 3,4], including cubic-ZrO_2 that provides direct evidence of extreme temperatures (>2300 °C). This approach has revealed an impact melt sheet origin for at least some of the lunar Mg-suite [2].

Here we explore the accessory mineral record of early crustal evolution on the Moon, via microstructurally constrained baddeleyite, zircon and Ca-phosphate geochronology of lunar meteoritic breccias. We have targeted feldspathic and anorthosite-bearing basaltic breccias from KREEP-poor regions of the Lunar Highlands, including Northwest Africa (NWA) 2200, NWA 10272, Yamato 981031, and Yamato 791197. These provide sampling of ancient lunar crustal rocks from distinct localities to Apollo Mission samples.

We report on occurrences of baddeleyite with cubic phase-heritage in many of these samples, alongside baddeleyite, zircon and Ca-phosphates with a range of microstructural complexity. Integrated petrological, microstructural and SIMS U-Pb geochronology results provide new constraints into the timing of early lunar magmatic events and distinct episodes of impact melt sheet reworking of the lunar crust.

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